

A Summary of some late Observations upon the Generation, Composition, and Decomposition of Animal and Vegetable Substances; Communicated in a Letter to Martin Folkes Esq; President of the Royal Society, by Mr. Turbervill Needham, Fellow of the same Society.

Paris, Nov. 23, 1748, N. S.

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Read Dec. 15. 22.
1748.

§ 1. **T**HO' I think myself now almost sufficiently qualified, by the Multitude of Experiments I have already made upon animal and vegetable Substances, since the 16th, N. S. of last *March*, to lay down some certain Truths upon this Subject, and from them to advance, by Induction, farther than so short a Period of Time would allow me to proceed by special Experiments, yet I would have your learned *Royal Society* look upon this Paper as an imperfect Sketch only of what I hope to publish from the Journals I have by me in a few Months, if these two or three Sheets are so fortunate as to meet with their Approbation. I am sufficiently sensible how much I may hurt this little Performance, if I promise too much, and raise in this Matter higher Expectations from the Public than it may appear hereafter to deserve: It is at this time therefore particularly the more necessary, that I should be exceedingly cautious to advance no Proposition rashly; nothing, but what seems to flow naturally from Observation. But this Precaution, however

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strict, will not exclude now-and-then a probable Consequence from appearing, provided it seems connected with some preceding manifest Truth; for such must be allow'd, as proper Foundations for a more exact Inquiry in a Matter I am very far from pretending to have exhausted. I must therefore observe, for my own Security against future Objections, that tho' I add no new decisive Experiment to my present List, or throw any more Light upon the Subject than what I have already amassed, I may possibly, before my Essay appears, whether by the Advice of Friends, or otherwise, conceive more mature Thoughts, reject some of the present, and adopt others in their Place. As this will be done, without affecting in any degree the main System, which I imagine turns upon unquestionable Truths, it is a Liberty I am persuaded that equitable and learned *Society* will indulge me in, if no other Consideration prevails, than the great Obscurity that hangs over a Subject so extensive and so intricate as this is; in which I am already engag'd much farther than I at first foresaw, and indeed too far to recede without saying something.

§ 2. I shall take as little Notice as may be, in this short Summary, of the almost inevitable Mistakes others may have made in this Matter before me, and the too hasty Consequences they have drawn from Appearances that naturally surprise by their Novelty. Such Surprise is but too apt to captivate Persons even of the most serene Thoughts, much more the young and unexperienced; such as Mr. *Hartsoeker* was, when he first discover'd the spermatic Animals.

§ 3. Mr. *Lewenhoeck* indeed, so near his Cotemporary in this Discovery as to claim a Priority, was much more advanced in Age and Experience; yet if he should also appear to have been mistaken, we are not to be surprised at it; for his repeated Observations upon the Sperm of such a Variety of Animals, even as low as Insects, seem to intitle him to draw Consequences as extensive for a general System of Generation, as his Experiments had been. In effect, what two more powerful Arguments could a Philosopher with the Knowledge of no other Fact, than that of their Existence, have, than the Universality of Animalcules in this Fluid, and their seeming Confinement to this animal Secretion?

§ 4. The Method of Reasoning by Analogy is but too apt to lead us into Mistakes, and therefore we ought to be very diffident of Consequences deduced this Way. Every new Appearance that has no known Cause, immediately fixes, and but toooften at last puts the Thoughts of the Observer upon the Rack. When the Mind arrives at this Intensity of Action, how natural is it to free ourselves from a painful Uncertainty at any rate, and that with as little Expence of Reflection as may be? The most obvious and easy Method is to class, if it admits it, and to reduce it to some other known *Phænomena*; possibly we are yet no nearer the physical Cause, because that of both is unknown. We have still, however, the Satisfaction to have diminished the Surprize it gives, by taking from its Singularity, and rest in some measure contented with this little Deceit.

§ 5. I call it a Deceit, if we acquiesce in it, till such time as a Number of Circumstances shall concur to

place it above the State of an Hypothesis, and shew us we have been right in our Inferences. Mere Analogy, founded only upon one or two Facts, and extended by Conjecture, however plausible, can but at most furnish Motives for a reasonable Doubt, and a more mature Enquiry. For tho', as a modern Author observes very well, Nature seems every-where to hold with itself, and go off by an almost imperceptible Gradation; yet, in our present Ignorance of the entire Chain of Beings, we are so liable to mistake two distant Species for the next immediate ones to each other, that the Analogy is thereby nearly extinguished, and its Traces almost effac'd.

§ 6. That this has been too much the Case in all the modern Systems of Generation, will appear I believe plain in the Course of this Memoir to every unbiass'd Naturalist. Animalcules were found universally in all animal Seed, almost at all times, and seemingly in this animal Secretion alone; they were therefore previously thought essential to Generation; or they should have added, a necessary Consequence of Properties in the Seed, which Properties were essential to Generation. But this Inference, however natural, was intirely overlook'd by them in their Reasoning; and Analogy induc'd them to stop at the first, without ever examining the second, tho' equally consequent. The Opinion of pre-existent Germs had prevail'd, under the Notion of Female Eggs, ere this Discovery was made; and thus one Mistake had been grafted upon another. When the spermatic Animals appeared, it was not difficult to transfer these imaginary Germs from the one to the other; and at most Philosophers were only

only divided by it; tho' as both Opinions were equally plausible, the latter generally prevail'd by its Novelty. The vast and unbounded Prospect it open'd to the Imagination, in a View of such a prodigious Series from the first Parent to the last, of original Lineaments, struck the Mind with an agreeable Surprise. The Folly of equivocal Generation, particularly as it had been stated by the Antients, the false Grounds they had proceeded upon to establish it, various Experiments that seem'd to prove every Animal, every Plant, descended from Individuals of the same Species; but, above all, the Facility of classing these spermatic Animals, the reducing them by Analogy to Seed and Eggs, and the known Transition of most Insects from one State to another, seem'd all sufficient to remove the Veil Nature had drawn, and furnish a Clue of a competent Length to conduct us into its most hidden Recesses.

§ 7. Thus this new System of Generation soon became a favourite Opinion of the last Age, as it is indeed still of this for the most part; and many ingenious Methods were imagined of answering the Difficulties from Observation that seem'd to oppose it. The more ancient Hypothesis of female Eggs was at last blended with it, and both were work'd up into one System: Their real Existence was determined, with their Form, Colour, Size, Situation, and the Mechanism of their Conveyance to the Womb; and imaginary Valves were appointed in each Egg admitting one, exclusive of every other spermatic Animal. Happy the first of these minute Beings that could take Possession of this little Cell, and shut the Door against contending Millions! Hitherto

therto every Step seemed easy and natural, if not too closely examined; the Inquisitive were conducted as high as their Curiosity could promise; and we might have expected, that Philosophers should have stopp'd here; but there is no End of reasoning by Analogy.

§ 8. No Body of Men so strictly deserves the Name of a Republic as that of the Learned does: Every one is passionately fond of adding to the common Stock, and claims nothing in Return, but the Name and Merit of having enrich'd it; yet this Passion is often so violent, that base Metals are mistaken for Gold, and Pebbles for Diamonds. It is not therefore Matter of much Surprize, if some have carried the imaginary Scene yet farther; and, still proceeding by Analogy, have supposed that the reticular Expansion, observed in the Womb of Does some Days after Copulation, by *Harvey*, and since him, in other impregnated Females, was nothing more than the investing Web, spun by the spermatic Animal before it enter'd the chrysalidal State, and preparatory to its Transition from one Form to another. Certainly these Authors never consider'd the immense Disproportion, between the great Expansion of this Web and the inconceivable Minuteness of the Animalcule; otherwise it had appeared as rational to suppose, that an *Alpine* Mountain could have been rear'd in a few Days by a single Emmet successively piling one Grain of Sand upon another. Nothing now seem'd wanting to complete this System, and place it above all Exception, but ocular Demonstration, if it might possibly be obtained, that the original Embryo was really contained

tained in each of these Animalcules: By Dissection, the young Butterfly had been observed in the Caterpillar three or four Days before it became a Chrysalid; Mr. *Lewenhoeck* had succeeded in some other very nice Operations upon extremely minute Subjects, nor did he despair of his Success in this; yet his repeated Attempts, it seems, all proved fruitless. But what the most exquisite Art had deny'd to *Lewenhoeck*, Chance, if we believe him, presented to another Naturalist, a little Man started from under the Integuments he was said to wear in his vermicular State; and the Observer very humourously gave us a Figure of this diminutive Entity perfect in every Member. These extraordinary Sallies, however, we must not place to the Account of the Learned, either of this or the last Age; they were generally exploded, and they indeed continue so; yet altho' they were peculiar only to the most lively; extravagant as they may appear to be, they were Consequences of the System; and thus was this Method of Reasoning by Analogy fairly pursued, as far as Imagination could carry it.

§ 9. *Cudworth, Grew, Le Clerc*, and some other Gentlemen of Judgment, had reflected too deeply upon Nature to give way to any Hypothesis, how plausible soever, that took in less than the whole Scene it exhibits to every attentive Observer. Yet they seem to have advanced much too far towards the other Extreme; and their System of plastic Natures, tho' in its Detail attended with many Proofs of extensive Thought, and profound Reflection, in a general View derogates as much from the
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Omnipotence of an All-wise Creator; and is not perhaps less extraordinary, than that Opinion which attributed the Regularity and Motion of the Planets to the Ministry of Angels. In this Light, I presume, it has been looked upon by others, as well as by myself; and it is upon this account that I imagine it has had so few Followers; I shall therefore take no further notice of it here, than to observe, that, inasmuch as it admits a productive Force in Nature, and Operations that go much deeper than a mere Developement of Parts, it has certainly more of Truth in it, than the Opinion of pre-existent Germs: as I flatter myself, will appear evident in the Course of this Memoir, by Arguments drawn not from Observations only, that are obvious to every Naturalist, but particular Experiments made upon animal and vegetable Substances, during the whole Summer of this present Year.

§ 10. To enter therefore more particularly into my Subject, where to place the pre-existent animal Embryo, for instance, whether in the Animalcule or Egg, was ever the Question, and still remains unanswer'd. A Division of vital, essential, and original *Stamina* or Lineaments was impossible; yet innumerable Instances in Monsters, Mules, and many natural Subjects, concur to prove, that the young *Fœtus* partakes of the Nature, Qualities, Constitution, Form, and Features of both the Parents; even as far as their Defects and Diseases, which are but too often hereditary. How can it then be agreeable to Reason? Or to what Purpose should we call in to our Aid unalterable original *Stamina*? Can the visible Species of any Production be deter-

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min'd by them, if every sensible Quality may be influenc'd indiscriminately by either Parent? And if they cannot be alter'd, nor the visible Species be determin'd exactly by them, in what does their Essence consist, or how can they be applied to that very Use we seem to think them designed for? If they are placed in the Animalcule, or in the Egg, how are they transmitted? And if in the Animalcule, why is the Process attended with so vast an Expence, so great a Waste of Millions of Entities, each containing within itself a Series of the most perfect and most wonderful Productions in Nature, when one only of these Millions of Millions is alone to take Place? How are these Animals generated? if in the common Way, not only the Process will be boundless, and these in their Seed have others, and so on in an immense Series; but they can not then be unalterable, because they are supposed capable of being generated. Further, if they float in the Air, or lie hidden in Food, as some have thought, how is it that the *Stamina* of one Species do not sometimes insinuate themselves into a strange Parent, with all the Inconveniences and Absurdities of equivocal Generation? Or if they are said to be excluded by proper Strainers adapted for that very Purpose in distant Species; at least they cannot be so in those Kinds that are near a kin: For if the spermatic Animal, which is naturally productive of a Horse in its own proper *Matrix*, is yet so fitted to the Eggs of the Ass, that it can possess a Cellule there exclusive of every other, which argues an exact Coaptitude, certainly the same Animalcules, if contained either in Food, Air, or Water, common to both Horse and Ass, might pass the

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Strainers indiscriminately of either ; and thus might we have Mules common from each respective Male, without a promiscuous Congress of these two Species.

§ 11. In another View, if we consider the extreme Tenuity, I may say the mere Nothingness of one of these *Stamina*, in its first Origin, at the Distance of many Ages ; comparatively to any one Part, the smallest muscular Fibre, for instance, of an adult Animal it is now said to constitute : how can we understand, that so minute a Filament could be developed, or in any Sense serve as a *Substratum* to a Cylinder so solid, so massive, so comparatively immense ? Could a Mountain be look'd upon as a Superstructure upon a Grain of Sand ? Or the terraqueous Globe derive its present Dimensions from the Dilatation of an Atom ? What is not the prodigious Force of this muscular Fibre in its present State, if compared with what it had in its Origin ? and, consequently, what must have been the Increase of real extraneous Matter, either by Apposition, or Incorporation ; which is now as much a Part of this Fibre as the original *Stamen* ? And if thus much can mechanically be assimilated, why not the whole of it formed by mechanical Causes ? Or why must so insignificant a Part of it be said to be concreated with the Universe ? But to strike at once with what, in my Opinion, may be look'd upon as a demonstrative Argument against the System of original *Stamina* ? The Difficulty still increases immensely, if we look into the Vegetation of Plants, and the wonderful Re-production of the Parts of Polypes, Starfish, Lobsters Claws, &c. The original

original *Stamina*, how minute soever, questionlets are diffused through the whole Production; since in this System all animal or vegetable Growth is made by Developement only: But if diffus'd, then some or all maybe by successive Bisection lost; and if lost, how can they be reproduc'd? Or if reproduc'd, why ever said to be original, and concreated with the Universe?

§ 12. These are but a few of those many Difficulties that might be enumerated; which yet are of such a Nature, that it is evident to every unbiass'd Observer, they cannot be even seemingly evaded, but by multiplying Suppositions on Suppositions; which at last render the Hypothesis so complex, as to retain no one Characteristic impress'd upon the ordinary Process and Operations of Nature. Is it not much more reasonable to say, that so many secretory Ducts, so many Strainers, so many preparatory Vessels in Animals, and such a curious Disposition in Plants for the Continuation of every Species, imply a Digestion, Secretion, and Preparation of Principles invariably, univocally productive of every Individual, when they fall into their respective *Matrices*, and find Aliment proper to assimilate? Are not these Principles contained in the Nourishment taken by the Parent Plant or Animal, the same that continually vegetate within it, and furnish it with Materials for its own Increase; continue to be distributed till it becomes adult, then plentifully exuberate, whilst it is, by new Preparations, fitted to propagate invariably in a proper *Matrix* its respective Kind? Else, why this Digestion? why this Secretion? why so many Strainers, Receivers, Ducts, and Valves? and why is some Food more productive of these Principles

ples than others? Or if they are pre-existent Germs that are secreted, are the pre-existent Germs of every Species contained in every Bird, Beast, Fish, or Plant, that supplies another with nutritive Juice, and becomes its Food? What a strange Confusion? How unlike that beautiful Simplicity, which Nature exhibits in all its Productions? Germs shut up within Germs, and Nature swarming with supernumerary Entities, all which we readily conceive might have been struck out at once, when the Universe was created; yet pretend not to be able to understand how they may be continually formed in Times successive, and as Occasions may require.

§ 13. This should seem as unnatural, and as unphilosophical, as it is disagreeable to Observation: For if every mix'd Body is made up by the Combination of certain Principles, I think we cannot question; but that God may have established Forces in Nature, subsisting Forces, by which such Principles may, in certain Circumstances, be invariably united, without any Danger of deviating, so as to render Generation equivocal; and if every Production in Question is a mix'd Body, as it certainly is, we know at the same time, that, how various soever they are, a small Number of Principles differently combined will yield an inconceivable Variety, sufficient to produce them all. Thus may we reduce Nature to what it is really ever found to be, simple in the Beginning of its Course, but magnificent beyond Expression when distributed: And this, I believe, will readily be allowed to be its true Process in Generation, if, besides taking in all the ordinary *Phænomena*, which no Hypothesis could yet explain,

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this Process is found consonant to many particular Experiments, some of which seem to me to render the System incontestable.

§ 14. Modern Naturalists have unanimously agreed to lay down, for a certain Truth, that every Plant proceeds from its specific Seed, every Animal from an Egg, or something analogous, pre-existent in a Parent of the same kind. If it is ever of Use to separate disagreeing Ideas, and previously to explain equivocal Words, it is particularly requisite in this Case to determine what we mean by Seeds and Eggs. Seeds and Eggs, in the common Acceptation of those Terms, are certain mix'd Bodies, of several Dimensions, that immediately furnish these Productions. In this Sense they are understood to contain not only the pre-existent Germ, but the *Nidus* also, if I may so term it, fitted for its Reception, and a due Supply of alimentary Principles to be assimilated in proper Circumstances. They are therefore thus far heterogeneous Bodies, that coalesce in a known Time; and their Principles are so far from being originally united at the Creation, that they sensibly come together from very distant Places in all hermaphrodite Plants, and from different Individuals in all those Species, where the Male and Female are distinct. Now I cannot persuade myself, but that either I have not understood what has been written on this Subject, or that Authors have not sufficiently reflected upon this, when they assert, that, because the *Plantula* is found in the Seed, an Oak, for instance, in an Acorn, that therefore this diminutive Tree bears likewise its Acorns, and thus on through a long Series.

Series. I shall not ask how this small Plant can have Seed ; in the common Acceptation of that Term, it is plain it cannot : and if it has not, where the pre-existent Germ is lodged ; how, from an Atom, at so immense a Remove, can it be increas'd to a sensible Mass, and be successively developed through so many Generations, till its Time of Appearance ? with many other Consequences that may be drawn from hence against the Reality of pre-existent Germs ; all which are too obvious to require a distinct Enumeration.

§ 15. It is in vain for us to pretend to lay down any one certain uniform Rule, and say to Nature, This is thy Scheme ; such are thy Statutes ; and from these thou shalt not deviate. If in many Productions she fixes it as an inviolable Law, that no Individual of that Species shall appear without a Co-operation of two Parents a Male and a Female, she has at the same time her Hermaphrodites both in Plants and Animals ; and if in these Hermaphrodites the two Sexes are yet so distinct, that she seems but to have a little diversified her Operations, without any sensible Deviation from her primitive Law, she will, in another Instance, that of the *Pucerons* observ'd by Mr. *Bonnet*, act either with or without the Co-operation of a Male. If again you say that a Female may be impregnated, so that the Impregnation shall diffuse itself, and penetrate as far as five or six Generations, she will point out to you in the Class of Polypes many Kinds, where Generation is carried on without either Male or Female, Egg or Seed ; tho', among these, there are some of the plumed Sort, where a whole Family, when by real Vegetation

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getation branch'd out as far as Nature designs, jointly concurs to give one Egg, or something analogous to an Egg, as the Source of a future Progeny. And thus is this Class united to its next most immediate Superior. If you should still insist, that the vital essential *Stamina* of every Plant and Animal were really concreated with the Universe, and are now diffused in Water, Earth, or Air, from whence each will be united to its proper Subject in due time; or that the Experiments of *Niewentyt*, and other Naturalists, of the Stems and Roots of Beans, or other Seeds, altering their Directions several times whendisplac'd, to recover each its own, the Root downwards, and Stem upwards; that these I say evidently prove vital, essential, unchangeable *Stamina*; as they must be, if original, and concreated with the Universe: Instances might be brought from the Memoirs of the *Royal Academy of Sciences at Paris*, of Trees that have been so inverted, and induc'd to change their Direction, that the Branches have become Roots, and the Roots Branches; a *Phænomenon* totally inconsistent with vital, essential, and unalterable *Stamina*. In fine, if at last you resolve to stand by this one Resource, that at least every Individual proceeds from a Parent like itself; that the original Germs, tho' not wholly unchangeable, are yet sufficiently fix'd to determine every Species, and that they are either lodg'd in these Parents, or secreted from the Elements by Strainers through their Bodies: I believe I can furnish, from my last Summer's Observations, a Cloud of Instances, of a new Class of Beings, whose Origin has hitherto been unknown, wherein Animals grow upon, are produc'd by, and, in
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the strict Sense of the Word, brought forth from Plants; then by a strange Vicissitude again become Plants of another Kind, these again Animals of another, and thus on for a Series, further than the utmost Power of Glasses can carry the most inquisitive Observer.

§ 16. It has generally been thought by Naturalists, that microscopical Animalcules were generated from Eggs transported through the Air, or deposited by a Parent Fly, invisible to the naked Eye, or even that assisted with Microscopes. Yet is it strange that no Naturalist should yet have seen them, if they are really so numerous, when their supposed Progeny is so various, and themselves must be thought to be so frequently gliding over the Surface of all stagnant Waters. By what extraordinary Turn is it brought about, might a Naturalist observe, that such surprising Revolutions should happen in these little Oceans, as a total Disappearance of one Species followed by the almost immediate Succession of another; and that in a manner so sudden and unexpected, that I know not whither they are retired, or what new Forms they may have assumed. If they die, does a whole Race perish together, without any known Cause? Or if they have taken any new Form, how is it that I see none of them altering, just alter'd, or expanding their little Wings upon these Waters, wherein I lately saw so many Millions in an aquatic State? If it is possible for them to become flying Insects in a manner totally invisible, why do not these new Parents again deposit their Spawn in the same Waters, and give a Succession of the late Species, that has disappear'd?

peared? The Element is not unfit for a new Progeny, since other Kinds succeed in it; nay I can transport from neighbouring Infusions some of the same specific Animalcules into these abandon'd Infusions, and they will live. Nor yet has the Generation of this Species any peculiar Season which confines it: A fresh Infusion of the same animal or vegetable Substance I apply'd before, will give me again in a little time the very Kind I am enquiring after, and that as often as I think proper to add new Matter. Thus might any Naturalist have reason'd, who had observed these Animalcules with some Attention; and been gradually conducted to doubt of their supposed Origin from flying Insects, or Eggs transported by the Winds.

§ 17. But there is yet a severer Difficulty, that springs from the Consideration of Paste-Eels: These Animals, Mr. *James Sherwood* and I, by performing a kind of cesarean Operation upon them, had the Pleasure to observe were viviparous; and the *Royal Society*, about the latter End of 1745, or Beginning of 1746, did us the Honour to give Attention to the Discovery, when Mr. *Sherwood's* Paper * was read, and the Experiments exhibited at one of its Meetings. I need not repeat what was at that time or has been since observed, where the Multiplication from one Eel once rose to 106. It is sufficient to observe, that these Animalcules musthence consequently be thought to have arrived at their ultimate State of Perfection; no longer liable to change, or to live in any other State; too weighty, even the least of them, to be buoy'd up by or transported

* See *Phil. Transf.* N^o. 478, p. 67.

transported through the Air, and too much of the aquatic kind to subsist out of Water, or to travel over dry Land, as I have often experienced, and any Gentleman may, by permitting the Water to evaporate. The Question therefore is, how, in a Mass from the clearest Spring-water, and the purest Wheat-Flour, heated as intensely as the Composition will admit, these Animalcules may be generated? It is not but that I think myself sufficiently enabled, by my Experiments and Observations, to answer all these Questions, and perhaps many more of greater Importance; but I have the strong Prejudice of near two learned Centuries, and the Opinions of Men of much more extensive Knowledge and Parts than myself, to stem and get over, before I can establish my own Sentiments upon this Subject; and therefore am willing to hope I shall not appear to have chosen a tedious and unnecessary Circuit, in tracing out the several Steps I have taken, to place my Conduct in a more rational Light. I must further observe, that I am obliged, previously to any of these Thoughts or Discoveries, to my Friend Mr. *Hill*, who translated and commented upon *Theophrastus* with so much Applause, for two Observations, made while I was at *London*, upon a Seed-Infusion he gave me, and the *Semen* of a Dog in his own House, which I, and some other Friends of the *Society*, saw; a Peculiarity singular enough was, that the Animalcules seem'd all hamper'd, and in some measure adhering by their supposed Tails, struggling as it were with a kind of oscillatory Motion to disengage themselves, and not advancing at all progressively. The Consequence of this Observation, which sufficiently hinted that they were then enascent,

enascant, and that their Tails were no Members given them by Nature to steer or swim withal, yet then escaped our Notice ; and was not plainly clear'd up, till other similar and more distinct Observations upon this Class of Animalcules occur'd some considerable Time after.

§ 18. It is now Time to observe how much I am obliged to Mr. *de Buffon's* Penetration, who first engaged me in this Enquiry, by his ingenious System, which he was pleas'd to read to me, and at the same time express'd his Desire I should pursue it, before I had myself any Thoughts of it, or any one Experiment had been try'd. He had been long dissatisfy'd with the Opinion of pre-existent Germs in Nature ; and he and Mr. *Maupertuis*, President of the *Academy of Sciences* at *Berlin*, had often discours'd together upon the Subject. We have several Hints of this Dissatisfaction, in a little Book, published by Mr. *Maupertuis* himself upon this Question at *Paris*, before my Arrival there ; in short, it was by general Reflections, and some other consequent Thoughts, that Mr. *de Buffon* was conducted to frame his System of organical Parts. These he supposed, by Coalition, to constitute the *prima Stamina* of all animal and vegetable Bodies, simple, uniform, common to all, and consequently to be found in a certain Quantity in every Portion of Food, Aliment, or nutritive Juice ; and from thence to be digested, and when the Subject became adult, secreted, and strain'd, for the Formation of the Seed of every Plant and Animal ; and in this Fluid or Substance to be consequently found in much Abundance. He further supposed these organical Parts to be moving when disengaged, living in Appearance, and gifted with certain Organs, but

extremely simple in their Composition ; being perhaps little more than elastic Springs more or less compress'd, more or less diversify'd in the Direction of their Force. He thought the Calamary Machines I observed some time ago to be strong Proofs of his Opinion ; and the spermatic Animalcules to be Machines, or organical Parts like these.

§ 19. For my own part, I was then, as I had been before, so far of his Opinion, as to think there were compound Bodies in Nature, not rising above the Condition of Machines, which yet might seem to be alive, and spontaneous in their Motions ; such as the calamary Machines would certainly appear, if they were render'd so diminutive as to conceal their Mechanism, and such I then suspected the spermatic Animals to be : for Motion in general was but an equivocal Argument, and did not necessarily imply Life in the common Acceptation of that Term. When, for a further Proof, I instanced Mr. *Hill's* Seed-Infusion, wherein many Bodies were seen to move in a manner very different from Atoms in a fermenting Liquid, and yet not so seemingly spontaneous as microscopical Animalcules, he added, that in his System it must be so ; that these were detached organical Parts, and that the Seeds, and particularly the Germs of Seeds in Plants, must necessarily abound with them more than any other Substances. Thus did our Enquiry commence upon Seed-Infusions, from a Desire Mr. *de Buffon* had to find out the organical Parts, and I, if possible, to discover which among these moving Bodies were strictly to be look'd upon as Animals, and which to be accounted mere Machines. In the Course of this
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Paper I shall be as exact as possible, in philosophical Justice. Whatever Experiments or Discoveries are to be ascribed to Mr. *de Buffon*, were the Result of his Directions, or jointly made with him, I shall so specify, that they may appear distinguish'd from all those others I made at home. The four first Infusions, among them one of Almond-Germs carefully pick'd out from between the two Lobes and Kernel, I mixed up at my own Lodgings, and then clos'd them in Phials with Corks. The Observations that occur'd, were, first, a Separation or Digestion of the Parts of these Substances, and a continual flying off of the most volatile. These offuscated my Glasses at every Instant, and, according to the Mixtures, yielded a fetid or an agreeable Odour; particularly that of the Almond-Germs, one strongly spirituous. Eight Days after they had been infus'd, I began to perceive a languid Motion in some of the Seed-Particles, that before seem'd dead; such as gave me Encouragement to prosecute my Enquiry. It was visible, that the Motion, tho' it had then no one Characteristic of Spontaneity, yet sprung from an Effort of something teeming as it were within the Particle, and not from any Fermentation in the Liquid, or other extraneous Cause. A distinct Atom would often detach itself from others of the same or less Dimensions; and whilst these others remained absolutely unmov'd, advance progressively for the Space of eight or ten of its own Diameters, or move in a little Orbit, then fall off languid, rest between two others, and detach itself again and again, with a Continuation of the the same Phænomena. The Consequences of these were obvious, the Motion was not spontaneous;
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for these Atoms avoided no Obstacle, nor had any other Characteristic of Spontaneity. It was not from any Commotion in the Fluid, Fermentation or the flying off of volatile Parts; because a large Atom would frequently move and detach itself from a much less absolutely quiescent: They did not seem to be enascent Embryo Animals, from a Deposition of any extraneous Spawn; for the Phials had been closed with Corks; nay they were the very Seed, or the Almond-Germ Particles themselves.

§ 20. These same Observations Mr. *de Buffon* made himself; for we examin'd these Infusions together a second time at his own House; and then it was that he order'd fifteen Seed-Infusions to be made up, which we continued regularly to examine twice a Week, till I propos'd to him to take them home, and follow them more closely by a daily or hourly Inspection, if necessary. The Result of our first Observations was, that tho' the Phials had been close stopp'd, and all Communication with the exterior Air prevented, yet, in about fifteen Days Time, the Infusions swarm'd with Clouds of moving Atoms, so small, and so prodigiously active; that tho' we made use of a Magnifier of not much above half a Line focal Distance, yet I am persuaded nothing but their vast Multitude render'd them visible. It seem'd therefore as if the first teeming languid Particles we had observed, vast in their Dimensions, if compared with those we now saw, had broke and divided into this immense Multitude of microscopical active Atoms. Then it was that we began to lay down a Distinction between animated and mere organiz'd Bodies; which, tho' far from being
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at this time groundless, yet afterwards proved to be false. These, and the spermatic Animals, we supposed to be of the latter kind; and to be produc'd in their respective Fluids, by a Coalition of active Principles, much as I had seen the Calamary Machines form'd by Hundreds, tho' absolutely detach'd, and swimming at Liberty in the Milt of the Fish: whilst we thought on the contrary, that the ordinary microscopical Animalcules, with strong Characteristics of spontaneous Motion and Animation, were to be class'd among Animals, and imagin'd them to proceed from Parent Individuals of their own Species. It was not till some time after this, that, determin'd to convince myself and others, without any Possibility of Doubt, whether these moving Atoms were really produced from without, or from the very Substance infus'd: I discover'd all the common microscopical Animalcules, the spermatic ones not excepted, were to be rang'd in the same Class, and that their Generation was very different from that of all other animated Beings.

§ 21. For my Purpose therefore, I took a Quantity of Mutton-Gravy hot from the Fire, and shut it up in a Phial, clos'd up with a Cork so well masticated, that my Precautions amounted to as much as if I had sealed my Phial hermetically. I thus effectually excluded the exterior Air, that it might not be said my moving Bodies drew their Origin from Insects, or Eggs floating in the Atmosphere. I would not instil any Water, lest, without giving it as intense a Degree of Heat, it might be thought these Productions were convey'd through that Element. Seeds or Plants were for this Reason

son improper, because they might have been judg'd to have been previously adhering to these Plants or Seeds: I neglected no Precaution, even as far as to heat violently in hot Ashes the Body of the Phial; that if any thing existed, even in that little Portion of Air which filled up the Neck, it might be destroy'd, and lose its productive Faculty. Nothing therefore could answer my Purpose of excluding every Objection, better than hot roast-Meat Gravy secur'd in this manner, and expos'd for some Days to the Summer-Heat: and as I was determin'd not to open it, till I might reasonably conclude, whether, by its own Principles, it was productive of any thing, I allow'd sufficient Time for that Purpose to this pure unmix'd Quintessence, if I may so call it, of an animal Body. From this time I take Corruption intirely in a philosophical Sense, for the rising of a dead Substance, by a new kind of Vegetation, into Life: and no Axiom, how much soever it may have been exploded, is more true than that of the Antients, *Corruptio unius est Generatio alterius*; though they drew it from false Principles, and so established it as to render Generation equivocal, and never penetrated sufficiently into Nature by Microscopes, to discover this Class of Beings, that are neither generated nor generate in the common Way, yet furnish a Key to lead to the Generation of all others. My Phial swarm'd with Life, and microscopical Animals of most Dimensions, from some of the largest I had ever seen, to some of the least. The very first Drop I us'd, upon opening it, yielded me Multitudes perfectly form'd, animated, and spontaneous in all their Motions: And thus was I oblig'd to abandon not only the

Notion preconceiv'd of a Distinction to be made in this Class of Animals, between those that appeared under a sensible Angle in the Microscope, and the atomical ones; but even that Hypothesis also which I had advanc'd as probable, in the little Essay I published in 1745, that spermatic Animals were no more than Multitudes of such Machines as those of the Calamary; for now it was plain of what kind they were, and whence they deriv'd their Origin.

§ 22. I shall not at this present time trouble you with a Detail of Observations upon three or four Scores of different Infusions of animal and vegetable Substances, posterior to these upon Mutton-Gravy; all which constantly gave me the same Phenomena with little Variation, and were uniform in their general Result: These may better appear at Length upon some other Occasion; let it suffice for the present to take notice, that the Phials, clos'd or not clos'd, the Water previously boil'd or not boil'd, the Infusions permitted to teem, and then plac'd upon hot Ashes to destroy their Productions, or proceeding in their Vegetation without Intermission, appear'd to be so nearly the same, that, after a little time, I neglected every Precaution of this kind, as plainly unnecessary. I take no notice yet of their Manner of being generated and generating; in relating these Discoveries, as I believe I shall be more intelligible, if I follow the Order of Time: It is a Justice moreover I owe both to Mr. *de Buffon* and myself; for some were made by him alone, some by me, and some of them in Concert together: His System, the Detail of his System, his Experiments, my own Discoveries, my Thoughts

in consequence of these Discoveries; all these were reciprocally communicated; we made a Secret of nothing to each other. Thus where one Truth seems to lead to, or is the natural Consequence of another, it will be easy, from the Order I have observ'd, to see how much I have been obliged to his Penetration and Foresight. But this will yet appear more distinctly, when our several Essays upon this Subject shall appear; and in the second Volume of his Natural History, which will very soon be published, I must declare for a Fact, that all which precedes his Accounts of the Experiments, begun *March* 16. *N. S.* of this present Year 1748, was previous either to his own Experiments or mine, and was read to me by himself.

§ 23. In this Order of Time therefore Mr. *de Buffon* not only repeated the Experiment I have taken notice of, and added particular Observations of his own, but made some intirely new in every respect, peculiar to himself. Among these, that never to be forgotten by Naturalists, which at once destroys the Opinion of Eggs in viviparous Animals, and shews the real Use of those reddish glandulous Bodies observed by *Vallisnieri* upon the Testicles or Ovaries, as hitherto call'd, of Cows. Every Anatomist knows, that the whitish Specks, near each of which a Hydatide is plac'd upon all Female Ovaries, were hitherto either look'd upon to contain the real Female Eggs, or to be the remaining Scars of Eggs fecundated and dislodg'd. *Vallisnieri*, nearer the Truth, thought the large reddish glandulous Bodies, which he calls Cherries, and found upon the Ovaries of Cows, and other Females, in the Time of their Heat, if the Animal is confined

to any particular Season, or at any Time, in those Females which are unconfined in this particular, were the real productive Organs contributory alone to Generation; yet still with a View to the antient Opinion of Eggs, for he supposed these glandulous Excrecences to be real oviparous Productions. Mr. *de Buffon*, on the contrary, long before Observation had realiz'd his Conjectures, rightly thought these to no more than temporary Blossoms, if I may so term them, not containing in their Cavity, which they have distinct when they are ripe, an Egg, but the real Female Seed; that the whitish Specks, scatter'd upon the Surface of Female Ovaries, were partly the remaining Scars of some of these temporary Blossoms now faded, as having perform'd their destin'd Office, or Embryo-Blossoms not yet expanded; that the Hydatid annexed to each of these contained a Quantity of imperfect indigested Seed; and that, if we took the Blossom in time, when it should be intirely ripe for Action, as when a Female is in Heat, or not barren, these red glandulous Excrecences would furnish a Fluid as really productive of true spermatic Animals, or organical Parts, as he calls them, as that of any Male observ'd by *Hartsoeker*, *Lewenhoeck*, or any other. The Result of these Conjectures was, that, ordering a Bitch in Heat to be strangled, and dissected immediately, we found two of these red Excrecences florid and ripe, one upon each Ovary, these, from their respective Cavities that ran obliquely under these Productions for near an Inch in Length, furnish'd a Tea-spoonful of a thick turbid Fluid; and this Fluid, observ'd in the Microscope with the most powerful Magnifier,

after some little time exhibited Numbers of spermat-
tic Animals, in every respect like to those hitherto ob-
serv'd by other Naturalists, animated, and moving
spontaneously. Thus was Mr. *de Buffon's* Conjecture
verify'd in every Particular.

§ 24. About this Time, I think some few Days
after, Mr. *de Buffon* in my Presence examin'd fe-
veral Sorts of male *Semen*; and then it was that,
for the first time, we fairly saw the spermat-
tic Animals enascent. Those Kinds which satisfy'd us in
this particular were extremely viscid, and contain'd
in a certain Quantity in the Chrystal of a Watch.
These Precautions are not unnecessary; for if a viscid
Kind be not chosen, and that in a good Quantity
together, such as that of Stags, &c. or any Seed of
the least exalted Sort, if I may so term it, as we
found some to be more so than others; it will alter
in the Atmosphere by an Evaporation of its volatile
Parts, which serve to hold it though but gently
together, after which it will liquefy, vegetate, ra-
mify into Filaments, and these Filaments again break
into moving Globules, especially if the Weather
be hot, before a small Portion can be adjusted to
the Microscope: whereby an Observer may easily
be imposed upon, and think the spermat-
tic Animals original and pre-existent, because he could not
discern that Action which produc'd them. This
Deception takes Place in all *Semen* of the more
exalted Kinds, such as particularly the Milt of Fish,
when it is in a State of immediate Impregnation,
and many others: For it is to be observed, that the
Semen of Animals is not at all times in an equal
State of Exaltation; and consequently that some Sorts,
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or even the same at different times, will at some give the spermatie Animals immediately, but at others not so soon, and perhaps not under some Hours: which is the Reason why they have often been said by Naturalists, and even by *Lewenhoeck* himself, not to have been found upon Inspection. By this it will appear, that we had tried many Sorts, before we had the good Fortune to meet with one, in that exact Degree of Exaltation necessary to exhibit the whole Process of this Vegetation; and so may others who shall be desirous of trying these Experiments after us: Yet, when they shall at last have obtain'd a proper Subject, one accurate View will be sufficient, and found to give the Key to the whole Secret.

§ 25. When we had seized this favourable Opportunity, we saw a small Portion of male *Semen* plac'd on the Microscope, first, as it were to develope and liquefy, then shoot out into long Filaments, ramify on every Side, these open and divide into moving Globules, and trailing after them something like long Tails; these Tails were so far from being Members given them to swim and steer by, that they evidently caus'd in them an instable oscillatory Motion; and were in Effect nothing more than long Filaments of the viscid seminal Substance which they necessarily trail'd after them; they were of various Lengths in various Animals, and they insensibly, by the continual progressive Motion of those Animals, grew shorter and shorter, till some of them appear'd without any at all, swimming equably in the Fluid. It was then plain how these Animals were to be class'd; their Origin was clearly to be deriv'd from Principles contain'd in

this Matter, either by an Evolution of organical Parts, as Mr. *de Buffon* supposed, or by a real Vegetation, as I thought, of the same kind with those I had before observ'd in my Infusions; tho' more prompt, because the Matter was more exalted: consequently the spermatic Animals were of the same kind as all other microscopical Animals, their Origin the same, their Influence nothing more in Generation, nor any otherwise conducting to its Cause, than as Effects of those Principles in the *Semen*, which alone are the true and adequate Cause of it. See *Fig. 1.*

These vegetative Powers, which, from the very Beginning of my Observations, I had found to reside in all Substances animal or vegetable, and in every Part of those Substances, as far as the smallest microscopical Point, I had at this time certain Proofs of; tho' not so plain and incontestable as those I procur'd a few Days before Mr. *de Buffon* left *Paris* for the Country, and which I prosecuted after his Departure. These I communicated to him in few Words the Night before he began his Journey, yet he was not at that time acquainted with any special Detail of the many Singularities that attend these latter Vegetations, for I had but just then made and enter'd upon the Discovery of them myself. I am obliged the more particularly to observe this, because the many Consequences he has since drawn, as well as myself, and which, without any mutual Communication, happen'd to tally with and seemingly to flow from the Discoveries, were not in Fact deduced from a circumstantiated Knowledge of these new Phenomena, which he had not, but from this one Principle, *that there*
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is a real productive Force in Nature; in which we had both long since agreed, however we may have differed in explaining that Action: For whether it be by an Evolution and Combination of organical Parts, as Mr. *de Buffon* supposes, or by a real vegetating Force residing in every microscopical Point, may be probably far beyond the Power of Microscopes to determine. But as the Principle from which we depart is intirely the same, it must necessarily lead to similar Thoughts, and similar Consequences.

§ 26. My first Proofs therefore were drawn from a close Attendance to all the common Infusions, particularly that of Wheat pounded in a marble Mortar. It was plain from them all, that after some time allow'd to the Water to call off the Salts and volatile Parts, which evaporated copiously, the Substance became softer, more divided, and more attenuated: To the naked Eye, or to the Touch, it appear'd a gelatinous Matter, but in the Microscope was seen to consist of innumerable Filaments; and then it was that the Substance was in its highest Point of Exaltation, just breaking, as I may say, into Life. These Filaments would swell from an interior Force so active, and so productive, that even before they resolved into, or shed any moving Globules, they were perfect Zoophytes teeming with Life, and Self-moving.

If any Particle was originally very small and spherical, as many among those of the pounded Seeds were, it was highly agreeable to observe its little Star-like Form with Rays diverging on all Sides, and every Ray moving with extreme Vivacity. The
Extremities

Extremities likewise of this gelatinous Substance exhibited the same Appearances, active beyond Expression, bringing forth, and parting continually with, moving progressive Particles of various Forms, spherical, oval, oblong, and cylindrical, which advanced in all Directions spontaneously, and were the true microscopical Animals so often observed by Naturalists. This brings to my Mind a Phenomenon often taken notice of, and seen with Surprise, Particles detach'd by the Reaction of the Water from the Extremities of the Fins of Mussels, which yet continue to move progressively. I think it sufficiently explain'd by these Observations; and that it is more than probable, that Mussels, Polypes, and other Kinds of this Nature, vegetate in a Manner analogous to this gelatinous Matter. See *Fig. 2.*

§ 27. In the Infusion of pounded Wheat, the first Appearances, after an Exhalation of volatile Parts, as in every other Infusion, were the second or third Day Clouds of moving Atoms, which I suppose to have been produced by a prompt Vegetation of the smallest and almost insensible Parts, and which requir'd not so long a Time to digest as the more gross. These in a Day or two more intirely disappeared; all was then quiet, and nothing to be seen, but dead irregularly formed Particles, absolutely unactive till about fourteen or fifteen Days after. From these uniting into one Mass sprung Filaments, Zoophytes all, and swelling from a Force lodged within each Fibre. These were in various States, just as this Force had happen'd to diversify them; some resembled Pearl-Necklaces, and were a kind of microscopical Coralloids; others were uniform
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throughout their whole Length, except just the very Extremity, which swell'd into a Head like a Reed, if the Force had acted equally on all Sides, or like the Head of a Bone at its Joint, if the Matter in its Expansion had bore to either Side. These Filaments were all Zoophytes, so teeming with Life, that whenever, upon taking a Drop from the Surface of this Infusion, I had separated the Extremity of a Filament so short as not to consist of above four or five Globules Chaplet-wise; they would advance progressively and in Concert, with a sort of vermicular Motion, for a little Way, then fall off irregularly to one Side, as if not yet fitted for progressive Motion, languidly turn their Extremities, and then again lie quiet for some little time. It was my Fortune however, not in this Infusion only, but in many others, to find some of these Chaplet-like Animals much smaller indeed than those of the Wheat-Infusion; but intirely regular, constant in their vermicular Motion, and which were consequently arrived to a higher Degree of Maturity and Perfection. I own I cannot but wonder to this Day at what I saw; and tho' I have now seen them so often, I still look upon them with new Surprize. Yet have these Phænomena serv'd me to very good purpose, and clear'd up many Difficulties in my former Observations.

The Origin of Blight in Wheat, Rye, and other Vegetables, was no longer mysterious: An Atmosphere charg'd to an extraordinary Degree with Humidity, now plainly appear'd sufficient, particularly while the Grains were tender and replete with a milky

Juice in a certain Degree of Exaltation, to produce in them this new kind of Vegetation, and to form their interior Substance into Filaments, which are indeed those very Eels I observ'd some Years ago in blighted Wheat.

This agrees perfectly with another Observation made by the Gentleman who translated my little Essay into *French*: Some of this blighted Wheat, two Years after I had gather'd it, I had given to Mr. *Trembley*, and he to this Gentleman. In a Note he has added, he observes, that these Filaments not only recover'd Life and Motion, after they had been so long dry, by macerating them in Water; but many broke, and discharg'd from within them Globules, which mov'd with extreme Vivacity. The Application of the foregoing Observations to this Case is easy and natural; nor is it now any Wonder, that these Filaments, the vegetative Force still residing within them, should move and resolve into Globules, or that they should have subsisted so long, full of that kind of Life they are actuated with, though dry and without Nourishment; for now they cease to be Eels, as I formerly thought them.

Blighted Rye, which is also so full of Filaments of this Nature, that the Grains are swell'd in their Diameters, and extended to an extraordinary Length by this new kind of Vegetation, exhibited nearly the same Phænomena when macerated, and is to be class'd accordingly. I am told by some of the Gentlemen of the *Royal Academy of Sciences* here, that in those Provinces of *France*, where this blighted Rye abounds, and is made up into Bread; it produces very strange Effects in the poor Country People who

feed upon it, many of which are here found in the Hospitals afflicted with a very singular kind of Mortification, which causes their Limbs to drop off.

There are two Sorts of Blight, in one of which the Grain crumbles into a black Powder; and the other is that which gives these moving Filaments or Eels. Mr. *Bernard de Jussieu* tells me, that one is from a Corruption of the Flour, and the other of the Grain.

It may not here be amiss to hazard a few Queries. Do not all Mortifications, and other Maladies in which there appears an extraordinary Exuberance of Matter in any one Part, proceed from a Weakness, a Want of Resistance, and from Principles of Union, which give to this vegetative Force, found to reside in every Point of animal or vegetable Substances, more Play in one Part than in another? For If the Resistance be not equal in all Parts, the exuberant Matter must break forth, and cause that Part to decompose; and if the Habit of Body be extremely lax, the Decomposition must continue; and that, in a certain extraordinary Degree, we shall call a Mortification. To rub a Wound, or any natural Sore, with Salt and Spirits, is found to be salutary, and preventive of Mortifications; and Salt I know, by Observation, will immediately put a Stop to these microscopical Vegetations, and cause the Animals to subside motionless to the Bottom: Therefore it is probable, that Salts and Spirits are Principles of Union, and productive of a greater Resistance in the ductile Matter acted upon by this vegetative Force. High Living, rich Wines, &c. are Preservatives against many contagious epidemical Distempers: Do not therefore these Maladies arise from a laxer

Habit of Body, and a more than ordinary Action of this same vegetative Force? And may not these, and many other Phenomena of this kind, be reduc'd to the same Principles? But this I leave to the Consideration of Physicians, who are better Judges of the Extent of these Observations and Principles.

The Substance emitted from the Globules of the *Farina fecundans* of all Flowers, by an Action I observed some Years ago, is also a Substance of this Nature, filamentous, and in a vegetating State: Nothing can resemble it more than the Fibres of most kinds of Mould; resolving all, as they do in Water, into others of a much finer Contexture, when the Vegetation, that had been before stopped by the nitrous Salts of the Atmosphere, begins by the Assistance of the Water to act again: And I know, by Observation, that all kind of Mould is formed by a Process of the same Nature as the Growth of these microscopical Plants; and to be class'd consequently with them, and reduc'd to the same Principles.

I cannot finish this Article without observing, that nothing can more perfectly than these wheaten Filaments, represent in Miniature Corals, Coralloids, and other Sea Plants, which have long been observ'd to be teeming also with Life, and have been suppos'd to be the Work of Animals, as it will appear to any one, that but inspects the Figure I have annex'd, and recollects my Description. Are not therefore all these in the same Class, and is not their Origin similar? See *Fig. 2.*

§ 28. But these Instances from common Infusions, of a vegetative Force residing in every microscopical Point of animal or vegetable Matter, how
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strong soever and surprizing, were neither so wonderful or extraordinary as some others I observ'd after Mr. *de Buffon's* Departure. From the wheaten filamentous Zoophytes it was easy to infer, that they sprung from, and were Productions of, the Mass of Matter that had subsided to the Bottom of the Phial. Yet this I could not obtain a Sight of; nor was it possible in this Way to observe them without separating them from their Roots and from the Mass, out of which they arose. The Method the most natural therefore which occur'd to me for the viewing of these Zoophytes, without disturbing their Vegetation, and for observing their whole Process, from the Origin of the Plants to their last Degree of Maturity, was to take extreme thin Slices of Cork, and insert, through little Holes which I made, four or five in each Slice, Grains of Wheat or Barley, or any other farinaceous Seed, for these all nearly agree in the Phenomena they exhibit, with the Germ either turned upwards, or carefully pick'd out with the Point of a Penknife, to prevent their usual shooting.

These were permitted to swim upon the Surface of fresh Spring-water, in a Glass exposed to the Sun, that the whole vegetating Force might be determin'd downwards towards the inferior Moiety of each Grain, which alone could in these Circumstances imbibe and be saturated with Moisture. This answer'd my Purpose intirely; my Plants grew downwards into the Water like Corals, but appear'd not till several Days after the Grains had been thus expos'd; and were at last so large and strong, that I could see them with my naked Eye.

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When they became thus visible, I cut off with a small Pair of Scissars the vegetating Extremity, and plac'd it in a concave Object-Glass with Water. The Plants then took a new Direction, follow'd the Expanse of the Fluid, and continued to vegetate, while I supplied them with Water, which I did from time to time, covering them after Observation with another concave Object-Glass, to prevent the Fluid from evaporating too fast. Thus I had for the Subject of my Observations what I may call a microscopical Island, whose Plants and Animals soon become so familiar to me, that I knew every animal Species, and every individual Plant almost without any Danger of Mistake; an Exactness so necessary, that it would not otherwise have been possible to follow the Process of this Vegetation without Confusion. From this time I laid aside the Use of large Infusions, and provided a certain Number of Watch-Chrystals, or concave Object-Glasses, for every Portion of animal or vegetable Substance I was to macerate in Water. The Use of these is plain and easy; many fruitful little Islands of various Kinds with Labels and Dates affix'd to each may thus be obtain'd, by placing the vegetating Substances in these Glasses; and this is the Method I would recommend to all those who shall be desirous to repeat or pursue my Experiments.

I find my Subject grows upon my Hands, and I am unwilling to take up too much of your Attention: I shall therefore finish these Observations by annexing a Figure of my Wheat-Island and its Productions, all which will be sufficiently intelligible without any more Words; and I shall reserve a
Multitude

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Multitude of other Observations I have by me in my Journals, upon Infusions and other vegetating Islands for the Essay, which I hope to publish in some Months, if these few Thoughts and Discoveries shall meet with Approbation. See *Fig. 3.*

§ 29. Yet must I trespass for a few Pages more; I cannot conclude this Letter without laying down some general Truths, and recalling these scatter'd Remarks to some certain Principles. A few Propositions of this kind, together with the probable Consequences, that seem naturally to flow from them, will not only make my System of Generation clear, but also take off many Objections, and render these very Observations better understood, when they are reduced under certain Heads.

It seems plain therefore, that there is a vegetative Force in every microscopical Point of Matter, and every visible Filament of which the whole animal or vegetable Texture consists: And probably this Force extends much farther; for not only in all my Observations, the whole Substance, after a certain Separation of Salts and volatile Parts, divided into Filaments, and vegetated into numberless Zoophytes, which yielded all the several Species of common microscopical Animals; but these very Animals also, after a certain time, subsided to the Bottom, became motionless, resolv'd again into a gelatinous filamentous Substance, and gave Zoophytes and Animals of a lesser Species.

This is not only true of all the common microscopical Animalcules, but of the spermatic also; which, after losing their Motion, and sinking to the Bottom, again resolv'd into Filaments, and again gave lesser Animals.

Animals. Thus the Process went on through all visible Degrees, till I could not any longer pursue them with my Glasses : And thus evidently the sper-matic are to be class'd with the common microscopical Animals.

Hence it is probable, that every animal or vegetable Substance advances as fast as it can in its Resolution to return by a slow Descent to one common Principle, the Source of all, a kind of universal *Semen*; whence its Atoms may return again, and ascend to a new Life. This common Element therefore, tho' uniform in its Origin and homogeneous, branches out into innumerable Species more and more compounded, more and more heterogeneous, as they depart and are further from this Source of organiz'd Bodies; yet may a Particle often be arrested, or moulded into other Bodies, long before it attains, which some perhaps never do, to this ultimate Resolution. Nor is there any Danger upon these Suppositions of falling into equivocal Generation; because the specific *Semen* of one Animal can never be moulded into another, and Seeds may differ specifically from one another by many invisible Principles totally unknown to us, and unattainable by Experiments; for we are very certain that the Power of Glasses, or Force of any *Menstruum* we can employ, must still leave us at an immense Distance from the ultimate Resolution of Bodies, in which alone they agree, and are homogeneous.

I say therefore the specific Seed of one Animal can never give another of a different Species; for, to be this *specific Seed*, it must have gone through many Changes from its first Origin, and have many Singularities peculiar

peculiar to itself, and acquired since it passed from the homogeneous Element, in which all Kinds coincide. The active vegetative Force that resides in it must be precise, its Quantity must be exactly proportion'd to the Nature, Solidity, Tenacity, Quantity, and Resistance of the ductile Matter it has to wade through, if I may so express myself; and these Combinations are very different in different Subjects, Thus much the many Strainers in every animal Body, necessary to extract this *Semen* from the Aliment we daily digest, and to prepare it, seem evidently to imply. Yet is not this, sufficient as it may appear to cause Varieties in the several Species of *Semen*, all that is to be consider'd: Times and Circumstances make Changes in it even during the Term of Gestation. What does not the *Fœtus* then undergo? and who can determine the Differences between *Matrix* and *Matrix*; between the Matter that is assimilated into a *Fœtus* in one Subject, and that in another; between the fixing Principles, the Quantity of Salts, Spirits, &c. in a Parent of one Species, and one of another; between the more copious or more limited Affluences of assimilating Matter; and between Times, where even single Minutes, Instants, &c. may be of the greatest Consequence? I see the Whole indeed, but confusedly; yet do I see the Source of a Variety; which, boundless as it were, if permitted to expatiate at full Liberty, is nevertheless invariably confin'd, by Him who made and rules the Universe, to a certain determinate Number of Species. Time, Action, Season, Quantity of Force, Quantity of Resistance, fixing Principles, Affluence of assimilated Matter, Direction,

and numberless other Variations, are all employ'd for His Purposes, and modell'd by that Almighty Power, which forms and directs the Whole.

Thus do these Principles, however capable of differing Combinations, yet admit only of a limited Variation, and never deviate further than is consistent with univocal Generation. Monsters, Mules, imperfect *Fætus's*, and other Instances of this kind, are but rare; and as they can be ascrib'd to nothing so properly as to the Obstacles they meet with, or to some accidental insuperable Resistance in the Matter of which they are formed, they do at least serve to shew that there is in Nature a real productive Force given it at its Creation; and that animal or vegetable Productions are not the Consequences of pre-existent Germs, plastic Natures, or of the immediate Hand of God himself, any more than the most regular Operations of the Planetary World.

§ 30. But to proceed in my Consequences from these Observations, all Naturalists must acknowledge, that the more compounded the organiz'd Bodies are, the less Danger there is of equivocal Generation in the Production of them; for thus the immediate Principles from which they spring, and their Circumstances during the Time of Gestation, must be much more varied than the more simple Bodies are, and at the same time be further removed, from that universal Element into which they may all ultimately be resolved: And even in the lowest Class of microscopical Animals, I can truly say, that I never yet observed any others than Productions specifically determined; the same Substances giving the same Plants and Animals, and in the same uniform Order

der and Descent. Nevertheless, tho' thus specifically determin'd, no one, that observes their Origin with the same Care as I have done, will be inclined to ascribe it to pre-existent Germs: It is therefore probable, as I just now advanced, that when we arrive at the lowest we can discover in this Class, we are yet at an immense Remove from the universal Source; notwithstanding that some of them are small beyond Conception, and no less simple in their Motions; which argues their Organization as simple, and seems to imply that there are among them, or not at a very great Distance from them, such as are only mere Machines, without any true Spontaneity.

I have myself seen a vast Gradation, and such a one as I have yet but an imperfect Notion of, in a Course of continual Observations made upon Infusions and Macerations of all kinds, from the most compounded to the most simple; from Animals of the largest kind to moving Atoms of the least; from Motions as slow to the most powerful Magnifier, as the Motion of the Minute-Hand of a Watch to Eyes unarm'd; from free Progression in all Directions to merely oscillatory Balances; which all seem to come to at last in the Course of their Decomposition, when they are just upon the Point of disappearing.

§ 31. Thus these Animalcules, if they may be call'd indifferently by that Name, manifestly constitute a Class apart; and their greatest Characteristic is, that they neither are generated, subsist by Nutrient, as other Plants and Animals do, or generate in the ordinary Way. This is indeed true, if the whole Class is taken in one general View: Yet is the Head of it united to the Species of the next im-

mediate Superior. The Bell-Animal, of which I have had many from my infused Substances, and whose Growth I have pursued from its first Origin, is a Species of microscopical Polype, generating and feeding as other Polypes do, when once itself is generated; tho' its own original Generation is perhaps different from that of the others; for I could never obtain any of the larger Kinds this Way. I say this however with some Reserve; for I will not assert but that some decay'd Water-Plants decomposing in particular Circumstances, and their Substance exuberating, may perhaps, when urged by this vegetative Force, give Polypes of every Kind; nay I very much suspect, that several of the lowest Kinds of visible Animals may, in due Circumstances, which yet perhaps are rare, be recoverable this Way, when the whole Species has perished in particular Places by some uncommon Accident. This I the more readily believe, from the Reasonableness of some Allowances to be made in this respect; all which may be permitted, and must have been foreseen by the GREAT CREATOR, without any Danger of Confusion, or an unlimited Generation of new Species never before produced: He who made Nature, and sees through the whole Machine, well knew its utmost Force, and has consequently foreseen every Circumstance, and limited its Productions accordingly.

Nor indeed can there be a stronger Argument deriv'd from any System of Generation whatsoever, of an All-wise Being, All-powerful, and All-good, who gave to Nature its original Force, and now presides over it, than from the Consideration of an exuberating ductile Matter, actuated with a vegetative

tive Force, limited, tho we know not its exact Bounds, in its specific Ascent or Descent, and expanding itself in Directions as certain and determinate, as the Motions of the Plants.

§ 32. These Thoughts will appear to be less hazarded, if due Attention is given to the Generation of the Paste-Eel. The *Royal Society* knows it to be viviparous; consequently perfect in this State, and such as may continue to generate in the common Way, as long as it has an Element and Matter proper for its Subsistence; yet is its own original Generation, as far as I can learn by Observation, as that of all these microscopical Animalcules, from a ductile vegetating Matter, the Produce of Wheat-Flour and Water; tho' it undergoes more Changes than others, and lives in other Conditions; ascending for some time before it enters its chrysalidal or Egg-like State, whence it comes forth a perfect Eel. I have added a Figure of a Group of these Eel-Chrysalids, but the Detail of their Metamorphosis I shall reserve for my little Essay, and not trouble you now with an Account too circumstantiated of every Observation. I have made upon them: Besides that I am not yet thoroughly satisfied in the whole Manner and Process of their Generation. See TAB. V. *Fig. 4.*

§ 33. But now, to obviate every Objection that may remain against the Existence of this vegetative Force, which seems to be the Key to much Knowledge, and to remove many Errors; it may be proper to add, that, besides ocular Demonstration, which any Naturalist may have, besides the Precautions I took, that no supposed Germs might either be convey'd through the Air or the Water, or remain adhering

hering to the Substances infus'd ; I have often, for these Purposes, made use not only of hot Broth, immediately closed up in a Phial, but also of pure animal Substances, such as Urine, Blood, &c. with the same Success; and in these, I believe, no one will suppose that Germs, Eggs, or Spawn, are pre contain'd, if Care is taken to close the Phials immediately.

Nay I have done more; I have, by reasoning consequently to my Principles, been directed to the Choice of many Experiments, all which I constantly found to answer my Expectation: I have thought, for instance, that the more exalted an animal Substance was, by a certain Degree of Decomposition, the more apt would it be to vegetate in a proper Matrix, and form the Part of a larger Animal; or, if it extravasated, to vegetate into the lesser; consequently, that if I took the milky Juice of germinating Seeds, or that thick turbid Matter which forms the Wing of a Butterfly in its chrysalidal State, these Matters must be more exalted than any ordinary Substances, and therefore give me these microscopical Productions so much the sooner: And in fact, I never, in these Cases, fail'd of seeing them within the Space of a few Hours, while ordinary Infusions did not give them under several Days.

Here it will be proper to observe, that Naturalists have thought the Butterfly's Wing pre-existent in the Caterpillar, because they discover'd the first Rudiments of it three or four Days before it enter'd the chrysalidal State; but it is then precisely that the Caterpillar first leaves off eating, tho' before extremely voracious; and that probably upon account

count of the Revolution it finds in all its Parts, while its Forces are otherwise employ'd, and the Collection of vegetating ductile Matter it had acquir'd by plentiful Diet, now as plentifully exuberates to form the Parts of the Butterfly. These Truths I am the better acquainted with, because I have particularly examin'd all those Substances: You cannot tear off a Portion of the Butterfly's Wing, even while in the Chrysalid, but you will find it in an Embryo-State, and the Matter which extravasates upon your Object-Glass, if mixt with a little Water to preserve its Fluidity, will almost immediately vegetate into these microscopical Productions. This argues an extreme Activity in it; from Activity follows Action, and an Effect, which can be no other than the Formation of the Wing it was contain'd in.

§ 34. Without instancing in many other Examples, where, by reasoning from these Principles, I was invariably conducted to certain Consequences, this last sufficiently leads to the Nature of animal or vegetable *Semen*. These latter are Substances of the same sort, but more exalted, and from thence adapted to a prompter Vegetation. Of this kind also, but not so exalted, was the gelatinous Substance I obtain'd by common Infusions.

The Exaltation however of Matter does not stop here; the lower I pursued this new Class of Beings in its Descent, the less was this vegetating Force clogg'd with resisting Matter, the swifter was the Motion of the Bodies, and the higher the Degree of Exaltation that produc'd them. This inclines me to believe, that an animal Substance may be exalted
this

this way into a Poison, a Venom, or a contagious Vapour. Hence stagnating Waters are poisonous and detrimental; and hence perhaps the vipereal Venom, or any other, may derive its Force; for these undoubtedly are all animal Secretions. Hence perhaps also arise contagious epidemical Distempers, from a Leaven thrown into the Blood by Exhalations of this kind. I am the more persuaded of the Truth of this, from the Consideration of Dr. *Mead's* Observations upon the Venom of the Viper: And swift moving Bodies, which subside and shoot into Filaments, seem manifestly to imply all these Consequences. I had myself propos'd last Summer to try the Effects of some of my most exalted Infusions, by instilling them into the Veins of Animals; but as yet I have had no Opportunities for these Experiments.

I might add other plausible Conjectures, that seem to be the natural Consequences of these Discoveries, relating to the Origin of *Ascarides*, *Teniae*, *Agaricks*, &c. nay, perhaps I could maintain them with Arguments that would seem convincing to most Naturalists; I might even further suppose, with some Probability, that the muscular Force, which acts against the interstitial Air in my Friend Dr. *Parsons's* most ingenious System, in one Word, that all the mechanical Forces of the Body, and the Impressions which affect the Soul, may be derived from, and ascribed to, this vegetating active Force when confined: But I am tired with extending my Views so far, nor do I at present see an End of the Consequences; the Subject and Principles appear so boundless.

§ 35. I shall conclude therefore with summing up my System in a few Words: I suppose all *Semen* of any kind to be an exalted Portion of animal or vegetable Matter, secreted from the Aliment of every generating Subject, when it is adult, and no further Demand is made for its Increase and Growth; this I suppose to be endued with a proportionable vegetative Force; to be various in various Circumstances, and heterogeneous in different Subjects; but to be uniform in its Productions, when it falls into a proper *Matrix*, where it finds Matter to assimilate, of a Quality and in a Quantity sufficient to form that specific Being; whilst in other Circumstances, it will, if it extravasates, by the same vegetating Force, yield all the several *Phænomena* I have above taken notice of. And thus, if I am not mistaken, I have obtained what I first intended to make out, that the spermatic Animals are not the efficient Cause of Generation, but only a necessary Consequence of Principles in the *Semen*, which Principles are necessary to Generation.

Thus have I connected my System with our Countryman Dr. *Harvey*'s Observation of that fine Tissue, or Web-like Expansion, observ'd in the *Uterus* of Does, in the Center of which the Embryo *Fœtus*, invested with its *Amnion* and *Chorion*, was found to be lodg'd: For let the Vegetation begin from the *Semen*, and continue to assimilate the affluent Matter from the *Matrix* wherein it has taken Root, and the Fawn must come forth like any other specific Animal or Plant.

I shall only observe, that *Lewenhoeck* had discover'd this vegetating Power in the *Semen*, and had

like Mr. *de Buffon* and me, seen the Filaments from whence the spermatic Animals spring; he even calls them Nerves and Arteries; and in one of his Letters to Mr. *Oldenburg* says, that he saw more in one Minute than the most accurate Anatomist could discover by Dissection in a Day: But when he afterwards chang'd this System, false as it was, of Nerves and Arteries for another, I believè, as false, that of pre-existing Germs in the spermatic Animals, he neglected to improve this Observation as he might have done; nay he afterwards took no farther Notice of it, but barely to say, that it was to be neglected. This Remark I had from Mr. *de Buffon*.

The Difference therefore betwixt Mr. *Lewenhoeck* and Dr. *Harvey* was, that the first had an Hypothesis to maintain, and the latter nothing in View but to follow Nature, without trusting too much to the first *Phænomena*, as I hope I shall appear to have done in this my Enquiry.

I had almost forget one Remark that coincides with my System; that although animal and vegetable Substances by a chymical Analysis appear to differ, they are nevertheless found by a natural Corruption to be reducible to the same Principles. This has been observed long ago by many Naturalists.

And now I think I have nothing more to add, only that I would be understood, when I speak of a productive Force in Nature, &c. to mean only a Force, which, tho' modell'd by the SUPREME CREATOR, goes no further than the mechanical and material Parts of a Man. I well know that we are composed of two very different Principles; and no one mere philosophical Truth whatsoever presents
itself

itself to me with more Evidence or Conviction than the Spirituality of our immortal Soul. All have ever allow'd Man in his Origin to be a kind of Plant or Vegetable before he is animated; and all rational Men have deriv'd his Animation immediately from the Fountain of Life, the true Source of all spiritual Substances. I think I have said no more; and thus only would be taken and explain'd.

The Principle of Life in other Animals I do not examine into, nor do I think it necessary. If they are truly spontaneous, as they seem to be, they have certainly some Principle distinct from Matter, which the GREAT CREATOR knows when and how to unite.

This Exposition, Sir, of my Sentiments, I thought might be necessary; not that I imagined that either you, or any of the Gentlemen of the learned *Society* in which you preside, would think my Principles any way tending to Materialism, from which no one can be more distant or averse than myself; for I well knew that I had nothing to apprehend from Persons of so much Judgment and Discernment, and who could not but clearly see, that there is really no Connection between those Principles, rightly explain'd, and the Doctrine of the Materialists: But I was willing to guard against the Misapprehension of others less acquainted with Matters of this sort, and into whose Hands this Paper might come, and have therefore taken these Precautions.

And now, Sir, I take this Occasion of returning my most humble Thanks both to yourself, and to the rest of the Gentlemen of the *Royal Society*, for the Honour I have received, in being elected one of its Members, and for which I have not been

able as yet to make my personal Acknowledgments I hope both you and they will accept these Thoughts favourably, which are humbly submitted to impartial Inquiry by the Author, who is, with the utmost Esteem and Respect,

S I R,

Your obliged humble Servant,

Turbervill Needham.

Explanation of the Figures in TAB. V.

Fig. 1. Represents the Origin of the spermatic Animals.

Fig. 2. The Wheat-Infusion.

Fig. 3. What I have called an Island in the Wheat-Infusion.

Fig. 4. A Groupe of the Chrysalids of the Paste-Eels.

Fig. 5. Is a Draught of one of the first microscopical Plants or Zoophytes which I discover'd; wherein *A* shews the Figure of the Plant throwing out its Animals, and *B* the same again after the Animals were discharged, again putting out a new Shoot from the Stem below, through the hollow transparent Head, to form a new Head, and produce another Generation.

VII. Obs.



Fig. 1. p. 644.

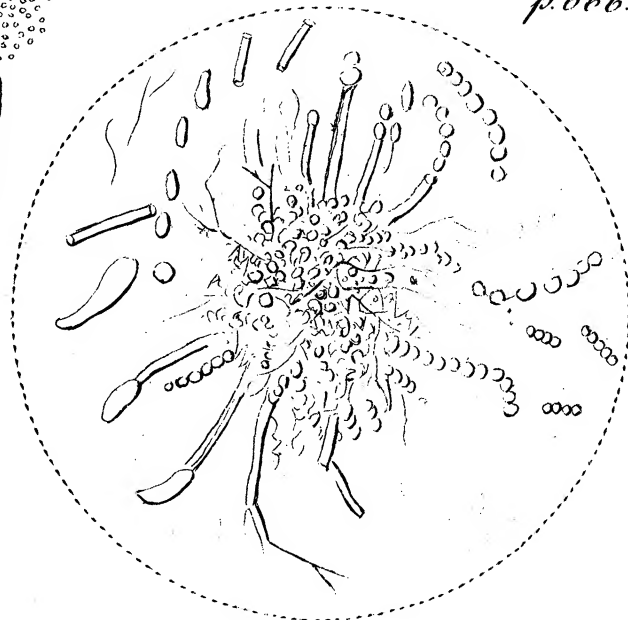


Fig. 2. p. 650.

Fig. 5. p. 666.

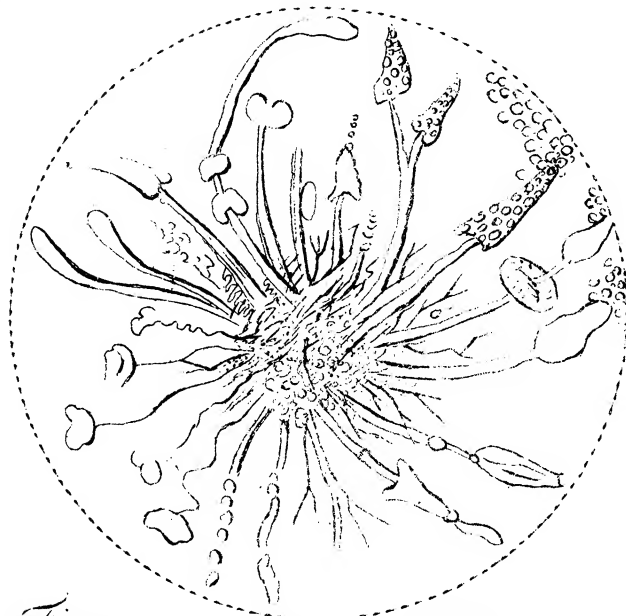
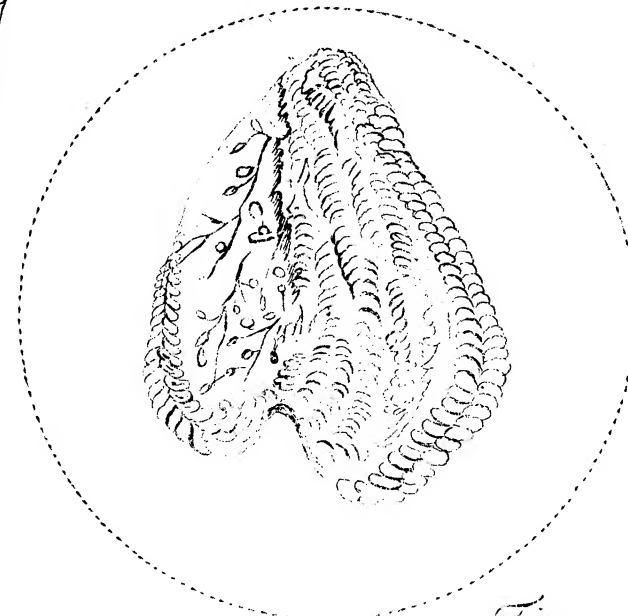


Fig. 3.

p. 653.



B



p. 659.

Fig. 4.